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# मौसम विज्ञान — ताप विद्युत सूर्य ऊर्जामापी — विशिष्टि

*Indian Standard*

# METEOROLOGY — THERMOELECTRIC PYRHELIOMETER — SPECIFICATION

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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Meteorological Instruments Sectional Committee, LM 21

## FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Meteorological Instruments Sectional Committee had been approved by the Light Mechanical Engineering Division Council.

Measurements of solar energy received by a surface held normal to the incident radiation is of importance in the study of absorptive and scattering properties of the atmosphere and the suspended particles in it besides application in various applied sciences particularly in fields using solar concentrators. The solar radiation which reaches the earth's surface is essentially in the wavelength range 0·3 to 4·0 μm. The irradiance on a unit surface is expressed in watt per square metres ( $Wm^{-2}$ ).

Direct solar irradiance is measured bv means of pyrheliometers, the receiving surfaces of which are arranged to be normal to the incident solar radiation. By means of view limiting diaphragms, only the irradiation from the sun and a narrow annulus of sky around the sun is measured. A sighting device helps in adjusing the pyrheliometer to be normal to the incident beam. The thermoelectric pyrheliometer is a field instrument which operates on the principles of thermoelectricity. A copper-constantan thermopile converts solar irradiation to thermo e.m.f., which can be either directly measured or recorded on a recorder, by mounting the instrument on a sun tracking arrangement.

# *Indian Standard*

# METEOROLOGY — THERMOELECTRIC PYRHELIOMETER — SPECIFICATION

## 1 SCOPE

This standard prescribes the requirements for a thermoelectric pyrheliometer.

## 2 DESCRIPTION

The pyrheliometer consists essentially of a thermopile sensor, consisting of about 40 pairs of copper-constantan thermojunctions formed by winding thin constantan wire toroidally on a former, a disc of perspex of diameter of about 18 mm and of about 4 mm thickness with a circular hole of 6 mm diameter and copper plating one half of each turn of the winding by electrodeposition. The points where the plated and unplated wires meet form thermojunctions. The plating is done in such a way that two sets of junctions are formed in the middle line of the opposite faces of the winding. An aluminium foil is pasted to the junctions on the upper surface of the former to have good thermal contact ( but electrically insulated ). The aluminium foil is painted black with optically black coating like Parson's optical black lacquer.

Another aluminium foil is pasted to the thermojunctions at the lower surface of the former in the same way. This foil is made to have a good thermal contact with the body of the instrument so as to have a steady cold junction temperature. On exposure to solar radiation a difference in temperature is established between these two sets of junctions, generating an e.m.f. which is a measure of the solar irradiance. The pyrheliometer can also be used to measure irradiances in different spectral bands by interposing band pass filters, mounted on a suitable holder, in front of the pyrheliometer.

## 3 MATERIAL

**3.1** The entire instrument shall be made of brass, unless otherwise specified.

**3.2** The thermoelectric sensor should be of about forty pairs of copper-constantan junctions on an acrylic resin former.

**3.3** The sensor should be mounted on a brass block, covered with tufnol cover, which serves as a sink to keep a fairly steady cold junction temperature ( Fig. 1 ).

## 4 DIMENSIONS

The instrument shall have the dimensions indicated in Fig. 1, 2 and 3. The cylindrical tube shall be about 305 mm long with about 38 mm internal diameter.

## 5 GENERAL REQUIREMENTS

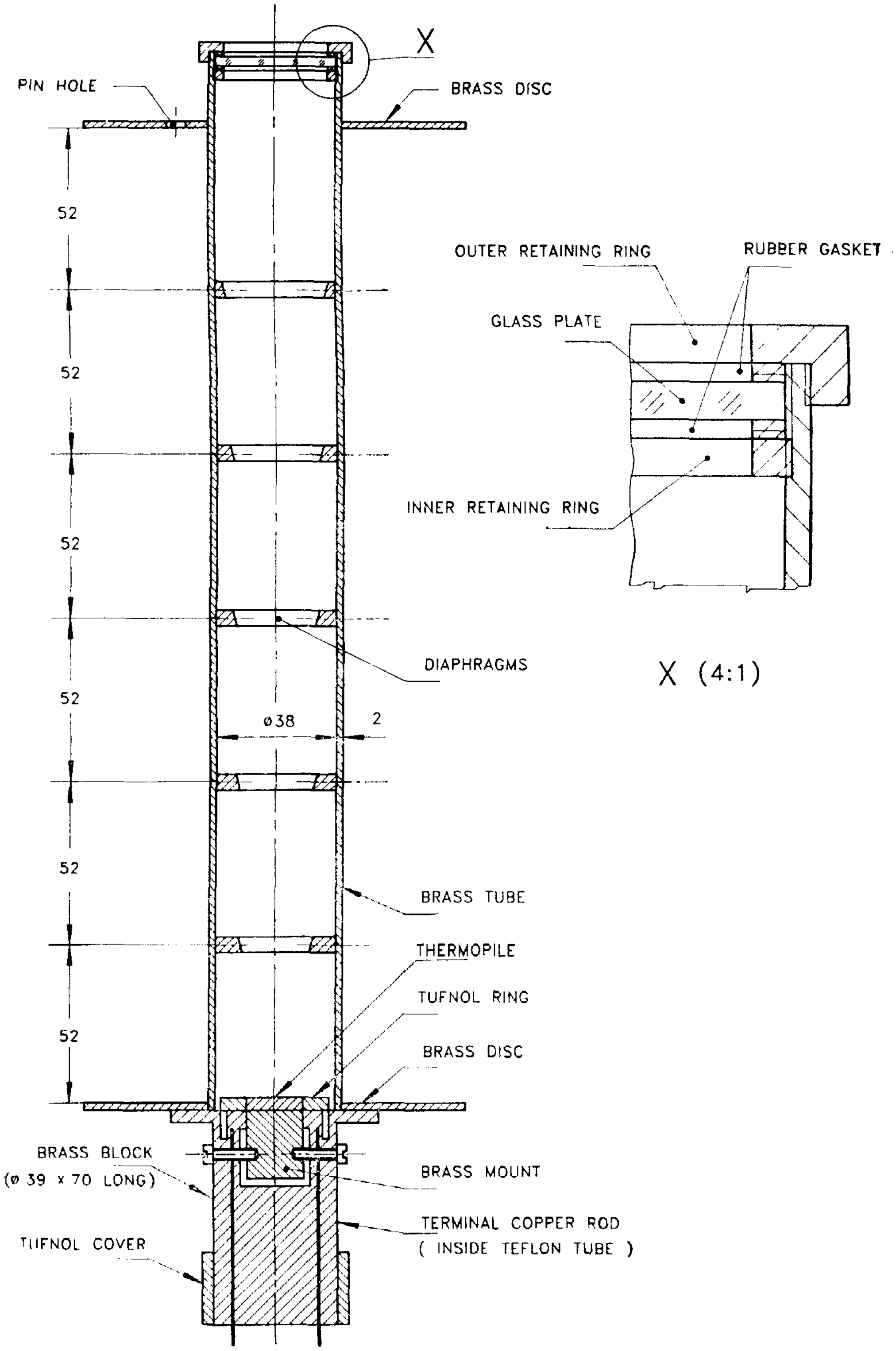
**5.1** The toroidal acrylic resin former on which the thermopile wire is wound shall have about 18 mm external diameter, about 6 mm internal diameter and about 4 mm thickness. The constantan wire to be used shall be of about 36 SWG. The window on the mount shall be of about 31 mm diameter. On the top of the tube a 5 mm knurled headed and threaded cap ( to retain optical plane glass ) shall be provided. The sensor shall be firmly mounted on the brass block as shown in Fig. 1 with a resin based adhesive which will provide thermally a good conduction and electrically a good insulation.

**5.2** The thermopile shall be pasted with a thin aluminium foil of about 0·02 mm thickness. The under surface of the foil shall be properly treated to ensure good electrical insulation but good thermal conduction. The resin adhesive shall be of extremely thin layer. The thermopile with aluminium foil shall be mounted on the brass mount using a thin layer of resin adhesive.

**5.3** The mounted thermopile and the tufnol mask shall be coated with black lacquer. Absorbtivity of the lacquer finish shall not be less than 98 % in the wavelength range 0·3-50 $\mu$m.

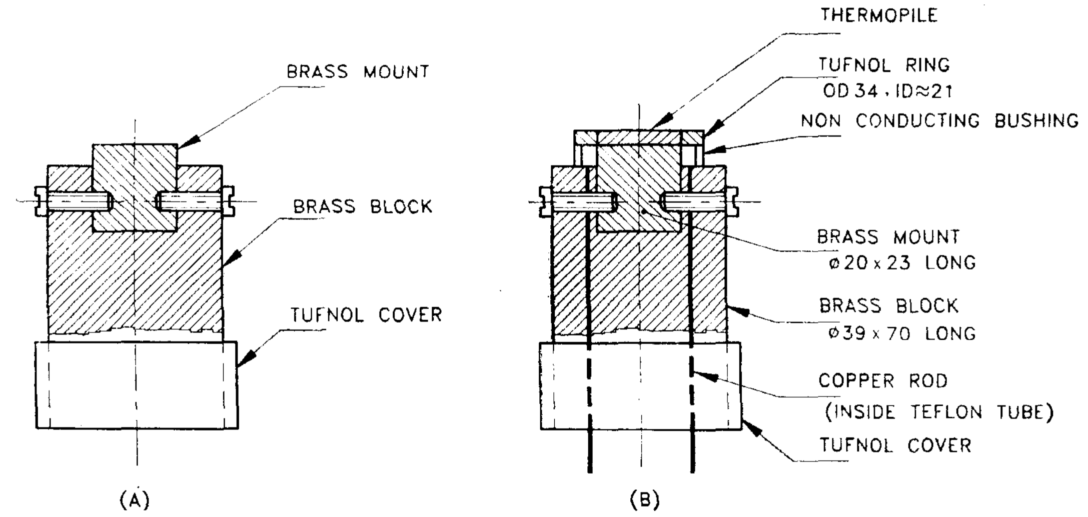
**5.4** A circular brass plate about 120 mm in diameter and 1 mm thick at a distance of about 22 mm from the circular window, shall be attached to the brass tube. A small pin hole shall be drilled at about 7-8 mm distance from the tube. Another identical plate shall be attached to the tube at its other extreme end and shall be provided with a small marking in tandem with the hole of the front plate. This is provided for orienting the instrument in the direction of the sun by the spot of light through the first plate to fall at the predetermined point on the second plate.

**5.5** Inside the tube, there shall be about 5 view limiting diaphragms placed at a distance of about 52 mm with respect to each other as shown in Fig. 1. The inner diameter of these diaphragms shall be 31, 27, 25, 23, 21 mm as arranged from the front. They shall be about 5 mm thick and have a tapered inner edge. They shall be coated matted black.



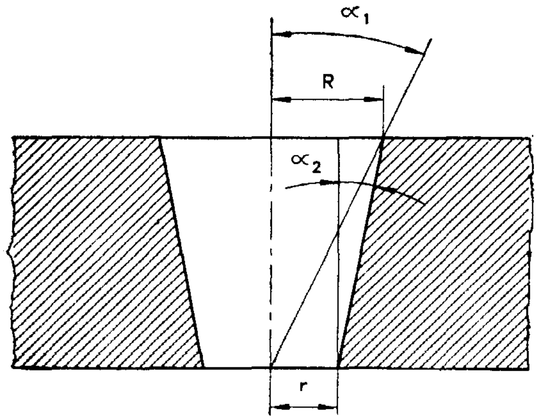
All dimensions in millimetres.

FIG. 1 DIMENSIONS OF THERMOELECTRIC PYRHELIOMETER



All dimensions in millimetres.

FIG. 2 BRASS BLOCK



$R$ — Radius at the entrance aperture
$r$ — Radius at the receiver
$\alpha_1$ — Opening half-angle 2·5° to 3°
$\alpha_2$ — Stope angle ≈ 1·0°

FIG. 3 VIEW LIMITING GEOMETRY OF DIAGRAMS

**5.6** The dimensions of the cut part of the diaphragms shall satisfy the view limiting geometry given in Fig. 3.

**5.7** The diaphragms shall be secured in position by means of brass screws.

**5.8** The front opening shall have a glass window. The glass shall be optically true and have uniform transmission from 300 to 4 000 nm. The glass shall have 1 or 2 mm thickness and 35 mm diameter. It shall be held in position in between two retaining rings and protected by a rubber gasket. The fitting shall be waterproof.

**5.9** The brass block housing the thermopile sensor shall be attached to the brass tube by means of 3 cheese head screws of about 2 BA. The bottom end of the block shall be covered by an insulating material like tufnol or bakelite to protect the brass from back radiation. The upper portion shall however be exposed to ensure the block being maintained at ambient temperature.

**5.10** The thermopile output shall be taken out through two thick copper wires fitted into the brass block. The copper shall be suitably insulated electrically by using thin non-conducting duct like a thin tuflon tube. The connecting wires shall be soldered to the copper wire and the junctions kept shielded by the protective cover.

**5.11** The pyrheliometer shall be provided with a mount suitable for use with a theodolite type of stand or on a solar tracking heliostat. The clamping arrangement which will hold the tube shall not obstruct the sighting device provided on the two guard plates.

## 6 FUNCTIONAL REQUIREMENTS AND ACCURACY

**6.1** Sensitivity : 5-8 $\mu VW^{-1}m^{-2}$

**6.2** Stability of calibration : ± 2 % per year

Spectral response : Flat within ± 0·2 % in the entire range of wavelength ( 300 to 4 000 nm )

**6.3** Non-linearity in response : Within ± 0·5 %

**6.4** Time constant for registering 90 % change shall be less than 25 seconds.

## 7 WORKMANSHIP AND FINISH

**7.1** Opening angle and the slope should be strictly adhered to be within the limit indicated in Fig. 3.

**7.2** Soldering shall be neat with minimum amount.

**7.3** All bare terminals should be suitably covered with sleevings.

**7.4** The black lacquer coating shall have 98 % absorption of the entire spectrum of the radiation. It shall be applied uniformly by spraying and shall be thin to avoid thermal gradient from the top of the coating to the aluminium foil.

**7.5** The tube shall be chromium plated and polished bright outside. Inside of the tube shall be painted matt black.

**7.6** All screws visible shall also be chromium plated.

## 8 MARKING

A name plate 55 mm × 15 mm with the following engravings shall be fixed on the lower circular plate with four screws:

a) Name of the instrument,

b) Manufacturer's recognised trade-mark, and

c) Serial number and year of manufacture.

## 9 TESTING AND INSPECTION

**9.1** Each pyrheliometer shall be tested individually for conformity to all the requirements of this specification.

**9.2** The equipment shall be provided with a calibration certificate. The calibration shall be traceable to the National Radiation Standards maintained at the Central Radiation Laboratory of the India Meteorological Department at Pune and expressed with reference to World Radiometric Reference.

## 10 PACKING

Each instrument shall be packed in its carrying case, suitably designed and provided with adequate cushioning and proper anchoring to avoid play during journey.

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